student will:

Select the statement that describes a half-wave dipole antenn

State the plane of distribution of H-lines around a half-wave dipole antenna. (3)

State the plane of distribution of E-lines around a half-wave dipole antenna. (6)

Draw the voltage standing wave and the current standing wave diagram of a half-wave dipole antenna at resonance. (10)

State the type of load presented to the transmission line by wave dipole antenna when the antenna is operated above its re frequency. (14)

State the type of load presented to the transmission line by wave dipole antenna when the antenna is operated below its re frequency. (18)

Match the types of fields with their descriptions. (25-26)

Select the formula used to compute the power of the induction field. (28)

Select the formula used to compute the power of the radiation field. (31)

Select the diagram that represents the radiation pattern of a vertically mounted half-wave dipole antenna. (38)

Label the beam angle, the half-power points, and the point of maximum radiation on a diagram of a radiation pattern. (40)

List three types of radiation patterns. (43-45)

State the two resistances that combine to determine the input impedance of an antenna. (52)

Define polarization. (54)

antenna. (65)

18. State the method used to compensate for end effect. (69)

SUGGESTED READING TIME 70 MINUTES

energy to the medium for propagation or radiatio

An antenna is defined as a conductor or system o ductors used either to radiate or to receive ele magnetic energy. In the study of antennas, the wave dipole antenna has been established as the reference. A half-wave dipole antenna, referred as the basic antenna, is the shortest antenna th resonates in free space.

The shortest antenna that will resonate in free is the ___________ dipole antenna.

---

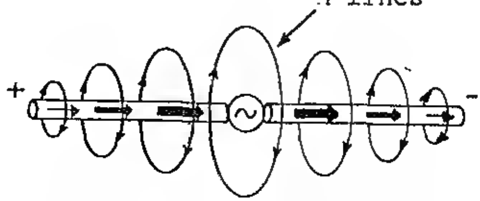
ave

2. The shortest antenna that will resonate in free space is the ____________ ____________

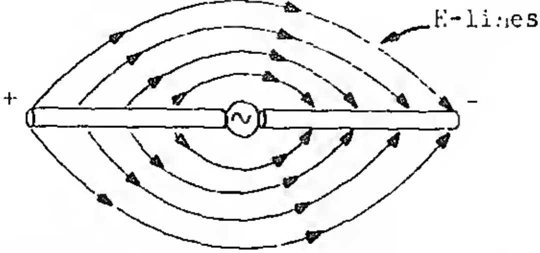
---

ave

3. Current flow through a conductor causes a magnet field to be built up. This field, called the H- is formed in a plane that is perpendicular to th antenna, as shown in the figure below.



	gradually becomes weaker toward the extremities o[f] antenna. The magnetic field, or H-field, around a half-wav[e] dipole is formed in the ________________ pl[ane] perpendicular/parallel
[perp]endicular	4. The magnetic field that is in a plane perpendicul[ar] to the half-wave dipole antenna is called the ___-field.
	5. Select the statement that describes a half-wave dipole. a. The longest antenna that will resonate in fre[e] space. b. The shortest antenna that will resonate in fr[ee] space. c. The longest physical antenna that requires a ground to operate. d. The shortest physical antenna that requires a ground to operate.
	6. Current flow through the conductor forms an elect[ro]static field along with the H-field. This electr[o]static field, referred to as the E-field, is form[ed] in the plane that is parallel to the antenna.



In the diagram above, the E-field starts at the positive end and flows toward the negative end of the conductor. The strength of the field increases at the center because of the heavy concentration of E-lines and then gradually decreases in strength as the extremity is reached.

The electrostatic field, or E-field, around a half-wave dipole antenna is formed in the ____________ (perpendicular/parallel) plane.

---

7. The electrostatic field in the plane parallel to the antenna is the ____-field.

---

8. The H-field has its strength at the center point of the antenna and is in the ____________ (perpendicular/parallel) plane.

---

9. Select the statement that describes a half-wave dipole antenna.

   a. The longest physical antenna that requires a ground to operate.

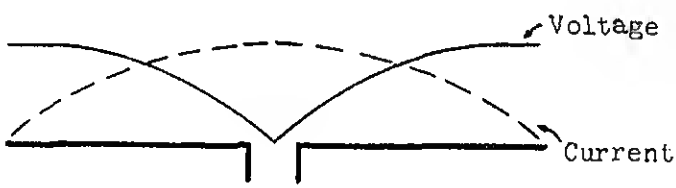
   b. The shortest antenna that will resonate in free space.

   c. The shortest physical antenna that requires a ground to operate.

dipole antenna are 90° out of phase. The positi the standing waves on the antenna causes the cen a half-wave antenna to appear as a series-resona point, and the load presented to the source appe purely resistive.

The current standing wave is maximum at the cent minimum at the extremities. The voltage standin wave is minimum at the center and maximum at the extremities.

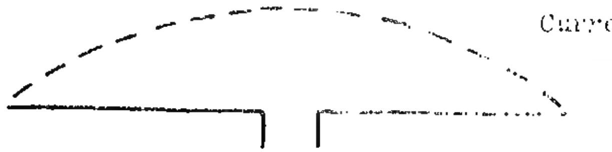
As shown below, the current and voltage standing waves are 90° out of phase on the half-wave dipo As long as the antenna is operated at resonance, relationship will exist.



When a half-wave dipole antenna is at resonance, center of the antenna has a voltage standing wav that is ______________ and a current standing w
maximum/minimum

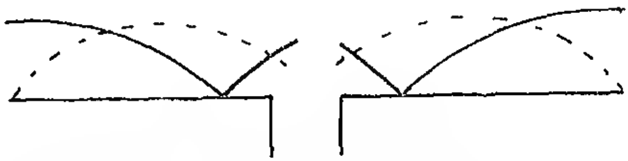
that is ______________.
maximum/minimum

half-wave dipole antenna at resonance?



oltage 	12. The electrostatic field, or E-field, is form plane that is _______________ to the perpendicular/parallel
allel	13. State the plane of distribution of H-lines a half-wave dipole antenna.
pendicular the enna.	14. At resonance, the voltage and current standi of the half-wave dipole antenna are 90° out however, if the frequency varies from the re frequency, the standing waves will shift the positions on the antenna, which causes the an appear either longer or shorter electrically This shift of the standing waves causes the effect presented by the antenna to change it

creased slightly above resonance, which causes the voltage standing wave to shift toward the ends of antenna. The antenna now appears longer, and the load presented to the transmission line by the antenna will appear inductive and resistive.



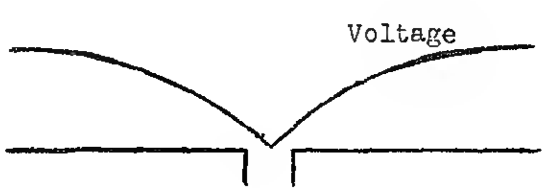
When the frequency increases slightly above resona the loading effect will appear ________________ and resistive.

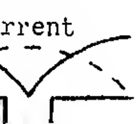
tive

15. When the antenna appears inductive and resistive, frequency has ________________ slightly from resonance.
increased/decreased

ased

16. On the figure below, draw the current wave of the half-wave dipole antenna at resonance.

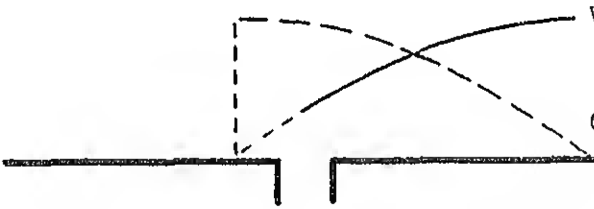




17. State the plane of distribution of E-lines around half-wave dipole antenna.

The half-wave dipole antenna slightly above resonance has the voltage standing wave leading the current standing wave, and the load appears inductive and resistive.

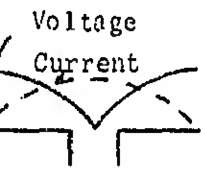
When the frequency decreases slightly below resonance, the standing waves again shift their relationship. This shift causes the current standing waves to lead the voltage standing wave. The antenna now appears shorter, and the load presented to the transmission line by tho antenna will appear capacitive and resistive.



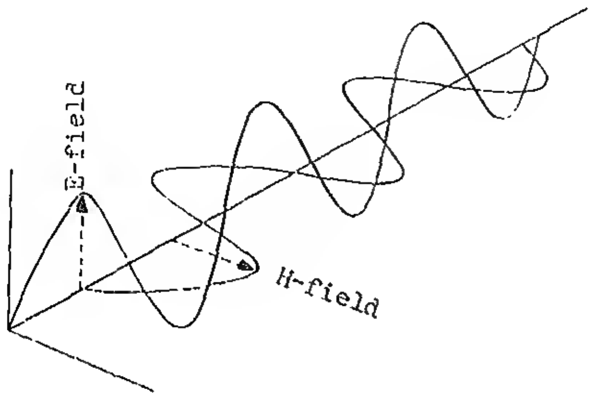
When the frequency decreases slightly below resonance, the loading effect appears ________________ and resistive.

---

19. The antenna appears as a capacitive and resistive load when the frequency ________________ from the resonant frequency.
increases/decreases

	When the frequency increases slightly above r the antenna load appears ______________ a ______________.
inductive resistive	21. Draw the voltage standing wave and the curren standing wave of a half-wave dipole at resona the diagram below. 
	22. When the frequency decreases slightly below r the antenna will appear as a ______________ and ______________ load.
capacitive resistive	23. State the type of load presented to the trans line by a half-wave dipole antenna when the a is operated above its resonant frequency.
The load appears inductive and resistive.	24. State the type of load presented to the trans line by a half-wave dipole antenna when the a is operated below its resonant frequency.

The electric and magnetic fields are at right angles to each other in the space around the antenna.



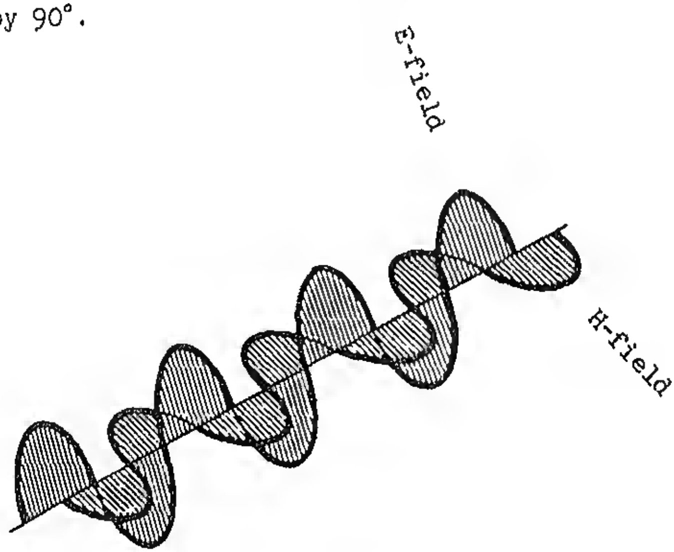
The magnetic field is composed of two <u>components</u> that are in phase in time.

The electric field is composed of three <u>components</u> that are not in the same time phase.

Because of the relationship of the <u>components</u> of the two fields, there are two separate electromagnetic fields produced. These electromagnetic fields are of prime importance to the operation of an antenna and are called the induction field and the radiation field.

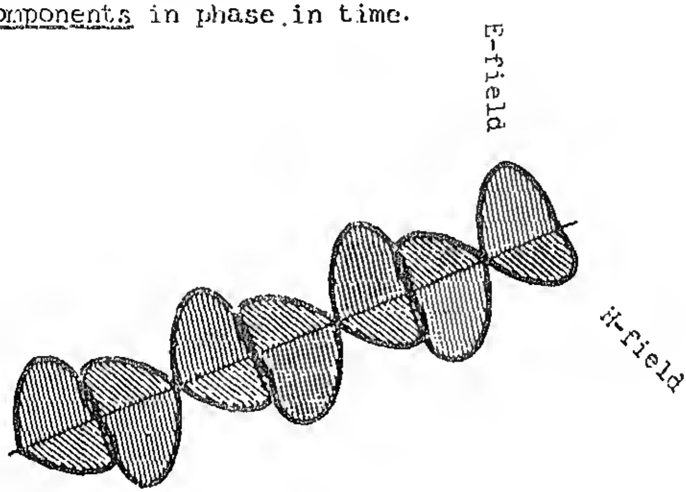
and the magnetic field; however, the components of the fields are out of phase in time. The induction field may be disregarded except in the immediate vicinity of the antenna. It has no part in the transmission of the electromagnetic wave.

In the figure below, the phase relationship is shown with the electric and magnetic fields at right angles to each other with the components displaced in time by 90°.



The field that is in the immediate vicinity of the antenna and has no part in the transmission of the electromagnetic wave is the _______________ field.

the fields are in phase in time. In the figure below, the electric field and the magnetic field are shown at right angles to each other with the components in phase in time.



The radiation field contains energy referred to as the electromagnetic wave, and this is the energy that is transmitted or received by the antenna.

Energy that escapes from the antenna is self-propagating and needs no medium, such as air, to travel through. It travels at a speed that approaches the speed of light.

The field that is referred to as the electromagnetic wave and is transmitted or received by the antenna is called the ________________ field.

A	B
____ (1) Induction field.	a. The electric field that perpendicular to the antenna.
____ (2) Radiation field.	b. The electric and the magnetic field in the immediate vicinity of th antenna.
	c. The field that increases strength as distance increases.
	d. The field that is transmitted or received the antenna and is refer to as an electromagnetic wave.

b.

d.

28. Even though the induction field and the radiation field are present at the same time, it is possibl compute the field powers separately.

The INDUCTION FIELD is composed of the electric f and the magnetic field with the components out of phase, and field strength varies inversely with t <u>square</u> of the distance.

In the INDUCTION FIELD, the strengths of the elec and magnetic fields vary inversely with the squar the distance from the antenna; therefore, $E = \frac{1}{d^2}$ and $H = \frac{1}{d^2}$, where E = electrostatic field,

etic field, and d = distance.

d = distance.

Select the formula used to compute the power of th

induction field.

a. $P = \frac{1}{d^2}$.

b. $P = \frac{1}{d}$.

c. $P = \frac{1}{d^4}$.

d. $P = \frac{1}{d^3}$.

29. The formula for computing induction-field power is

a. $P = \frac{1}{d^4}$.

b. $P = \frac{1}{d^3}$.

c. $P = \frac{1}{d^2}$.

d. $P = \frac{1}{d}$.

30. The field that is transmitted or received by the antenna and is referred to as an electromagnetic w is the ________ (induction/radiation) field, while the field is in the immediate vicinity of the antenna but ha effect on the radiated wave is the ________ (induction/radia field.

the RADIATION FIELD are stated as $E = \frac{1}{d}$ and $H =$

The radiation-field power is the product of the electric and magnetic fields and is stated as $P = \frac{1}{d^2}$.

Select the formula used to compute power of the radiation field.

a. $P = \frac{1}{d}$.

b. $P = \frac{1}{d^3}$.

c. $P = \frac{1}{d^4}$.

d. $P = \frac{1}{d^2}$.

---

32. The formula for computing radiation-field power

a. $P = \frac{1}{d^4}$.

b. $P = \frac{1}{d^3}$.

c. $P = \frac{1}{d^2}$.

d. $P = \frac{1}{d}$.

33. Which of the following formulas is used to compute the power of the induction field?

a. $P = \frac{1}{d^3}$.

b. $P = \frac{1}{d^4}$.

c. $P = \frac{1}{d}$.

d. $P = \frac{1}{d^2}$.

34. Match each field in column A with its description column B.

A		B
____ (1) Induction field.	a.	The field that increases strength as distance increases.
____ (2) Radiation field.	b.	The electric field that is perpendicular to the antenna.
	c.	The field that is transmitted or received by the antenna and is referred to as an electromagnetic wave.
	d.	The electric and the magnetic field in the immediate vicinity of the antenna.

35. Which of the following formulas is used to compute the power of the radiation field?

a. $P = \frac{1}{d^3}$.　　c. $P = \frac{1}{d}$.

b. $P = \frac{1}{d^4}$.

c. $P = \frac{1}{d^2}$.

d. $P = \frac{1}{d^3}$.

37. Select the formula used to compute the power of

radiation field.

a. $P = \frac{1}{d^2}$.

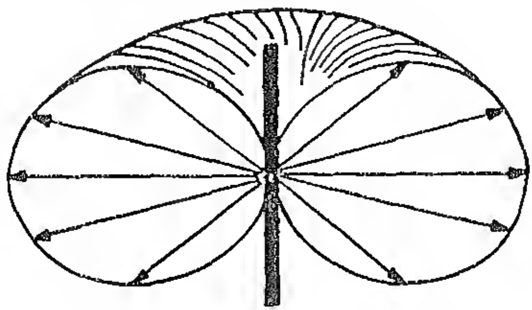
b. $P = \frac{1}{d}$.

c. $P = \frac{1}{d^3}$.

d. $P = \frac{1}{d^4}$.

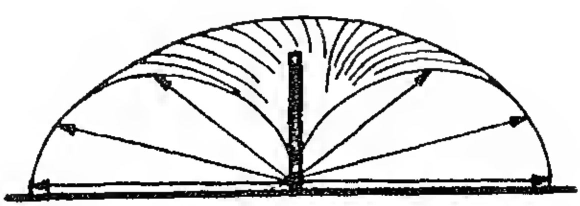
38. The radiation pattern of an antenna is determin measurin the field strength at all points arou the antenna at a constant distance and plottin readings on a polar graph.

The figure below shows a cross-sectional view of the radiation pattern of a half-wave dipole antenna mounted vertically in free space.



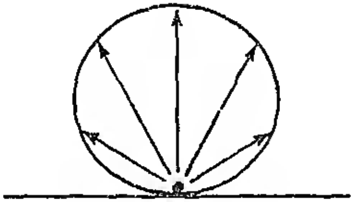
The radiated energy completely encircles the antenna and resembles a doughnut with the antenna in the center. At the ends of the antenna, a minimum amount of energy is radiated.

When the antenna is mounted vertically with one end terminated on the ground, the radiation pattern appears to resemble a dougnut cut in half, as shown below.

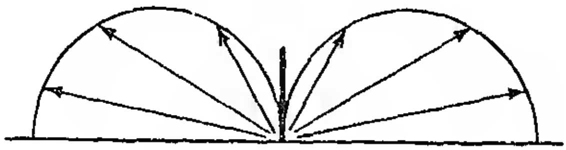


When a half-wave dipole antenna is vertically mounted the radiated energy encircles the antenna, and the ends of the antenna radiate ________ energy.

a.



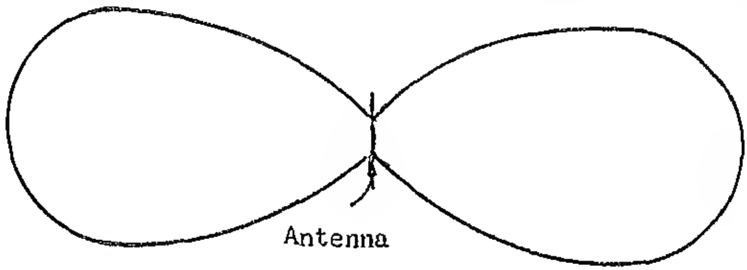
b.



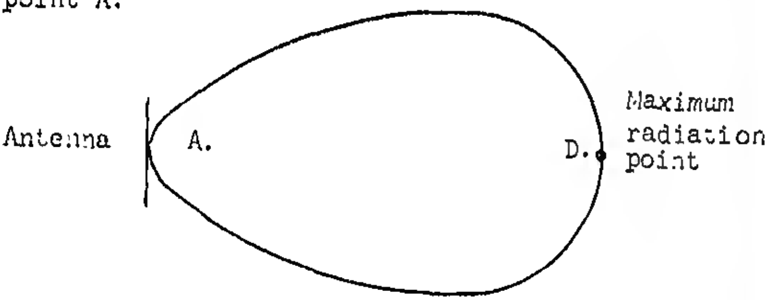
c.

40. Energy radiated by an antenna other than a vertically mounted half-wave dipole antenna forms a radiation pattern that contains a beam angle, a maximum radiation point, and half-power points.

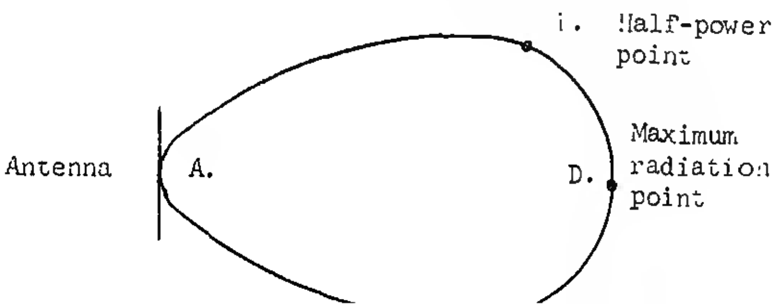
The pattern of a horizontally mounted half-wave dipole antenna as viewed from above is shown below.



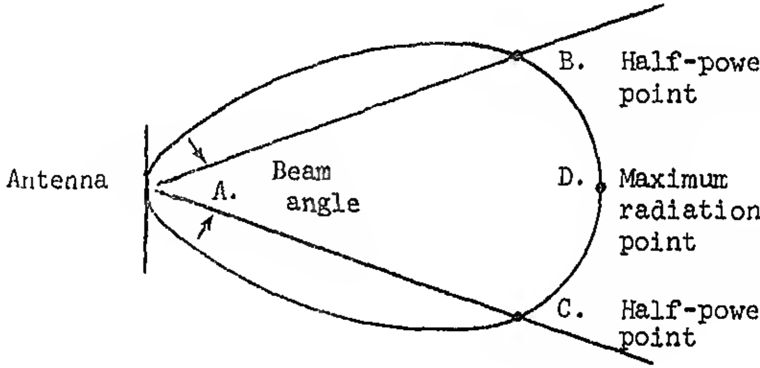
For simplification, only one-half of the pattern will be used. The maximum radiation point, point D, which is the point of the concentration of E-lines, is the point on the pattern directly opposite the antenna, point A.



The points on the radiation pattern where the energy is equal to 0.707 of the maximum energy are the half-power points. These are labeled as points B and C.



angle.

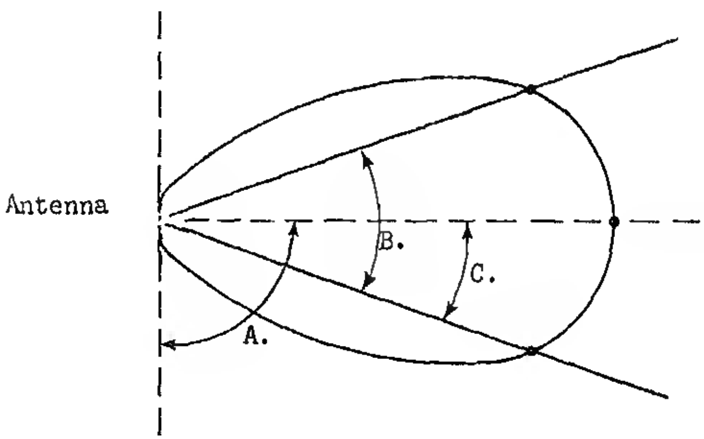


The energy at the point directly opposite the bea

angle is ______________.
maximum/minimum

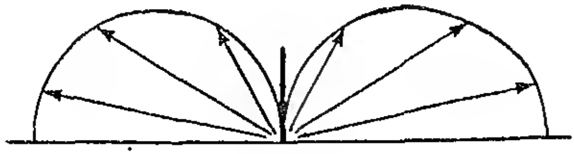
ium

41. Select the angle below that is the beam angle.

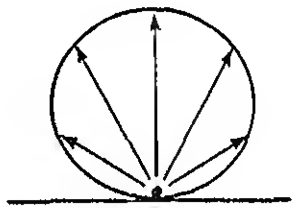


radiation pattern of a vertically mounted half-wa

dipole antenna.

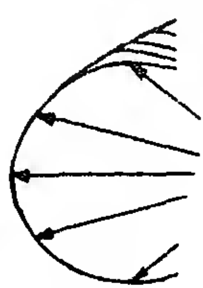
a. 

b. 

c. 

43. There are many types of radiation patterns. The three most widely used are the omnidirectional, th bidirectional, and the unidirectional patterns.

The radiation pattern of the vertically mounted ha wave dipole resembles a doughnut, as shown in the cross-sectional view below

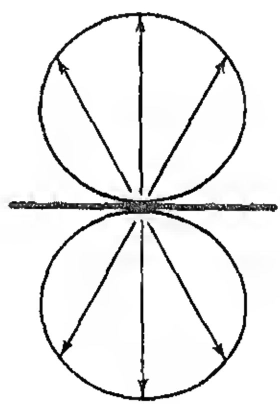


same in all directions from the antenna.

A vertically mounted half-wave dipole radiates

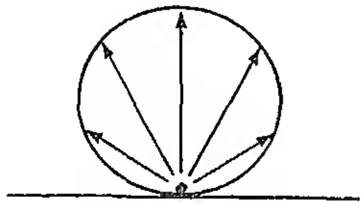
______________________ pattern.

bi-directional	44. To obtain bidirectional characteristics, a half dipole antenna is mounted in the horizontal pla Viewed from above, the radiation pattern appear shown in the figure below. Maximum energy is radiated in two directions from the antenna.



A horizontally mounted half-wave dipole antenna radiates a/an ____________________ pattern.

to use a reflector. The figure below shows the end view of the pattern that is radiated by a horizontally mounted half-wave dipole antenna at ground level. The ground acts as a reflector, and the energy is radiated in a vertical beam.



The three types of radiation patterns most widely used are the ____________, the ________________, and the _____________________________.

---

46. List three types of radiation patterns.

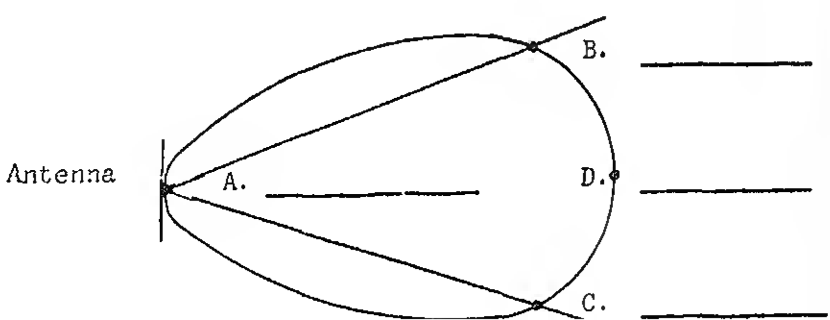
(1)

(2)

(3)

---

47. Label the beam angle, the half-power points, and the point of maximum radiation on the diagram of the radiation pattern below.



Half-power point

Half-power point

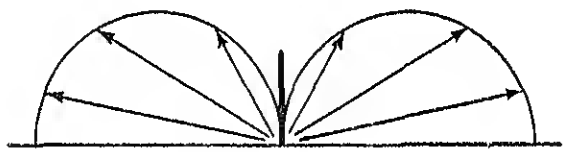
Maximum radiation point

radiation pattern of a vertically mounted half

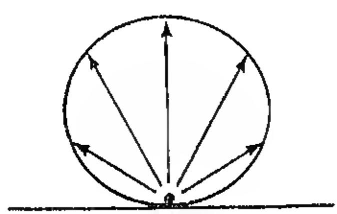
dipole antenna.

a.

b.



c.



name in column B.

A

B

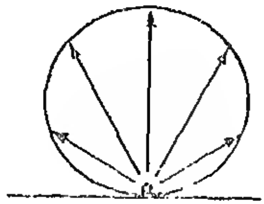
a. Bidirectional.

b. Omnidirectional

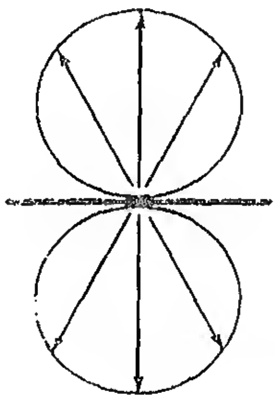
c. Vertically polarized.

d. Unidirectional.

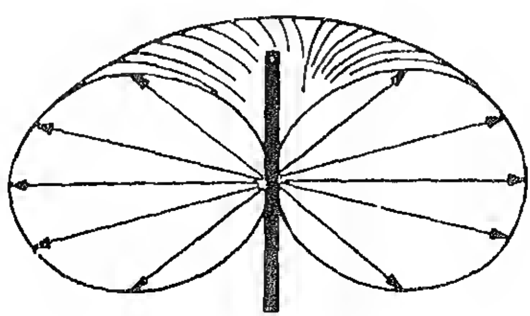
____ (1)

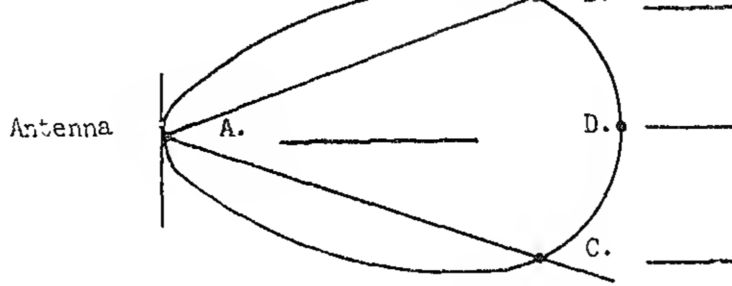


____ (2)



____ (3)





Beam angle Half-power point Half-power point Maximum radiation point	51. List three types of radiation patterns. (1) (2) (3)
ni-rectional. directional. directional.	52. Antennas have power losses that must be replac the source. These losses are caused by the in at the input of an antenna. The input impedance is a combination of two resistances--the resistance of the conductor a radiation resistance. Radiation resistance is amount of resistance required to dissipate the amount of power that is actually radiated fro

When the half-wave dipole antenna is operated at its resonant frequency, it offers a purely resistive load of 73 ohms to the transmission line, which is the minimum input impedance.

Although radiation resistance accounts for the majority of the input impedance, the conductor also dissipates power because of the current flow through it. The length of the conductor and the type of material affect the resistance of the conductor.

Select the two resistances that determine the input impedance of an antenna.

a. Conductor resistance.

b. Resonant resistance.

c. Radiation resistance.

d. Capacitive reactance.

53. List the two resistances that determine the input impedance of an antenna.

(1)

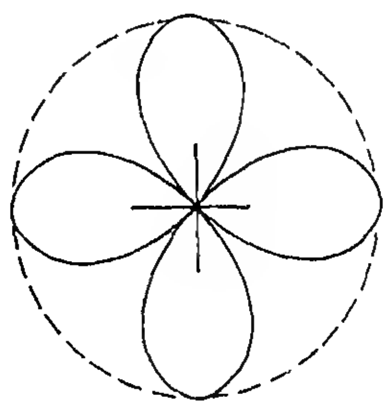
(2)

adiation
esistance.

the mounting of the antenna.

A vertical dipole radiates a vertically pola
wave. Most transmissions below 2 MHz are ve
polarized. TV and FM broadcasts normally us
horizontally polarized antennas. To receive
maximum signal, the transmitting and receivi
antennas must have the same polarization. A
antenna that is polarized in the same plane
axis (direction of mounting of antenna) is s
linearly polarized.

Circular polarization is produced by using t
linearly polarized fields that are perpendic
each other and have a 90° phase differential



Polarization is defined as the orientation o
electric field ______________________

56. Which of the following resistances form the input impedance of an antenna?

a. Radiation resistance.

b. Capacitive reactance.

c. Resonant resistance.

d. Conductor resistance.

57. Antenna gain, which is a figure of merit, is the ratio of the maximum power output in a given direction to the input power.

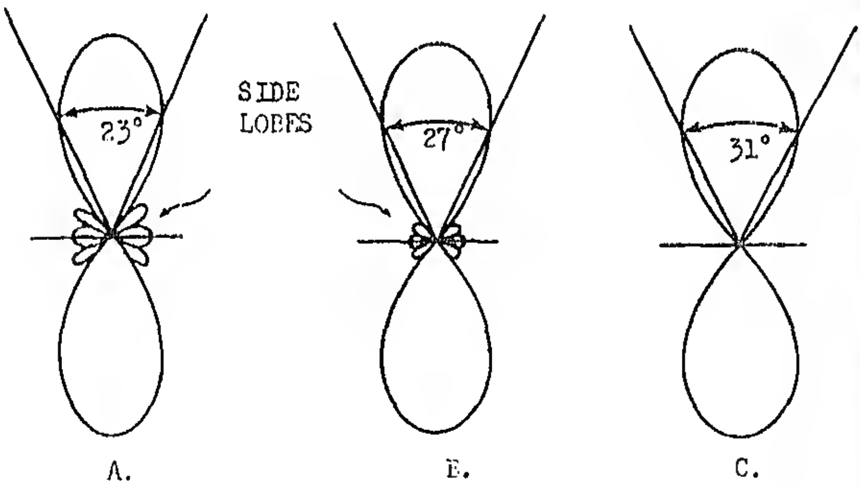
In antenna theory, GAIN is inverse to beam width. When the beam width increases, the power is dissipated over a larger area, and the gain decreases. For an antenna to obtain a large gain, the beam width is made as narrow as possible.

The gain of an antenna increases when the beam width is ________________.
increased/decreased

58. An increase in beam width causes antenna gain to ________________.
increase/decrease

orientation the electric ld in the ection of iation.	60. State the two resistances that combine to deter the input impedance of an antenna. (1) (2)
ductor istance. iation istance.	61. The bandwidth of an antenna is the band of frequencies that an antenna can respond to and radiate with maximum efficiency. The bandwidth determine proper operation and is influenced by several factors, some of which have already bee discussed: radiation pattern, gain, polarizati characteristics, and impedance characteristics. Another factor affecting bandwidth is the side- level. The side lobe consists of radiated ener not contained in the main beam and is basically low-power area of stray radiation constituting loss of main beam power. A change in the side-lobe level affects bandwid just as a change in beam width affects gain. W the side lobes are reduced or eliminated, the b width increases, which causes a decrease in gai

In figure A below, the side lobes are large in size and the beam angle is 23°. In figure B, the side lobes have been reduced in size and their energy added to the radiation pattern, which causes the beam angle to increase. Figure C shows the radiation pattern with the side lobes eliminated. All the energy is radiated, but with a marked increase in the beam angle. This causes a loss in gain which affects the bandwidth.



List the five factors which affect bandwidth.

(1)

(2)

(3)

(4)

(5)

obe	(4) (5)
ion n. zation. nce. obe	63. A decrease in beam width causes antenna gain t _______________________________.
se	64. Define polarization.
ientation electric in the ion of ion.	65. Because the velocity of r-f energy in a conduc different from that in free space, the electri length and the physical length of the antenna be different. There are three factors that af the electrical length.

material with a dielectric constant greater than one decreases the velocity of the electromagnetic wave.

2. Size.

An increase in the circumference of the antenna is the same as an increase in the plate area of a capacitor. Both cause the capacitance to increase. This increase causes a decrease in the velocity of the electromagnetic wave.

3. End effect.

Objects of metal or dielectric material near an antenna will also cause a change in velocity of the electromagnetic wave, owing to the stray capacitance caused by these objects. This stray capacitance is called END EFFECT, because the ends of the antenna are made farther apart electrically than physically.

The three factors that affect the electrical length of an antenna are:

(1)

(2)

(3)

	(3)
Conductor material. Conductor size. End effect.	67. Select the factors that affect the bandw antenna. a. Radiation pattern. b. End effect. c. Gain. d. Impedance. e. Polarization. f. Side-lobe level.
a. c. d. e. f.	68. State the effect that a decrease in beam the gain of an antenna.
Increases.	69. To compensate for end effect, it is nece shorten the antenna physically by 5 per per cent. By physically shortening the antenna by 6 per cent, ______ ______ is overcome.

	circumference of the conductor, and its locati objects of metal or dielectric material affect electrical ______________ of an antenna.
h	72. List five factors affecting the bandwidth of a antenna. (1) (2) (3) (4) (5)
tion rn. ization. ancc. lobc .	73. The method used to compensate for end effect ____________________ to shorten the antenna physically/electrically 5 per cent to 6 per cent.
cally	74. List three factors that affect the electrical of an antenna. (1) (2) (3)

ctor

ffect.

the
na
cally
cent to
cent
er.

You have completed this program.
Review the objectives on pages i and ii.
If you do not completely understand an objective, turn to the frame/s indicated by the number/s in parentheses.

REFERENCES:

1. Antennas. AN-374A. Philco-Ford. Pages 2 to

2. Basic Electronics. NAVPERS 10087-B. Washing
U. S. Government Printing Office. Chapter 1
pages 352 to 360.

3. Electronic Circuit Analysis, Vol. II. NAVWEPS 00-80-T-79. Washington: U. S. Gover
Printing Office, 1963. Chapter 13, pages 13-
13-17.

4. Terman, Frederick. Electronic and Radio Engineering. Fourth Edition. New York: McGr
Hill. Chapter 23, pages 864 to 867.

Select the statement that describes a half-wave dipole antenn

a. The shortest antenna that will resonate in free space.

b. The shortest physical antenna that requires a ground to

c. The longest antenna that will resonate in free space.

d. The longest physical antenna that requires a ground to o

State the plane of distribution of H-lines around a half-wav
dipole antenna.

State the plane of distribution of E-lines around a half-wav
antenna.

Draw the voltage standing wave and the current standing wave
half-wave dipole antenna at resonance on the diagram below.

State the type of load presented to the transmission line by
wave dipole antenna when the antenna is operated slightly ab
resonant frequency.

State the type of load presented to the transmission line by
wave dipole antenna when the antenna is operated slightly be
resonant frequency.

____ (2) Radiation field.

received by the antenna ar referred to as an electro- magnetic wave.

b. The electric and the magnetic field in the imme vicinity of the antenna.

c. The field that increases i strength as distance incre

d. The electric field that is perpendicular to the anter

Select the formula used to compute the power of the induction

a. $P = \frac{1}{d}$.

b. $P = \frac{1}{d^2}$.

c. $P = \frac{1}{d^3}$.

d. $P = \frac{1}{d^4}$.

Select the formula used to compute the power of the radiation field.

a. $P = \frac{1}{d}$.

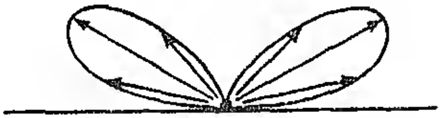
b. $P = \frac{1}{d^2}$.

c. $P = \frac{1}{d^3}$.

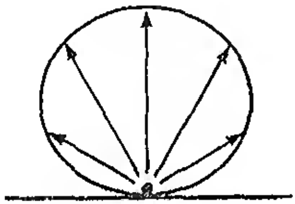
d. $P = \frac{1}{d^4}$.

t the diagram that represents the radiation pattern of a
cally mounted half-wave dipole antenna.

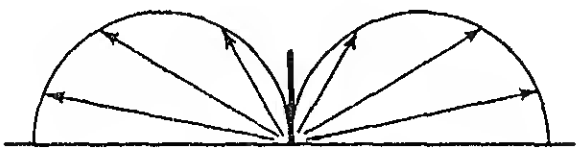
a.



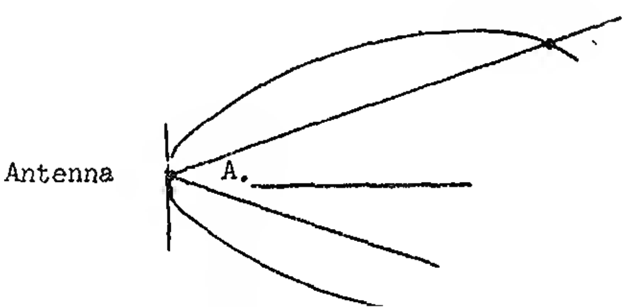
b.



c.



the beam angle, the half-power points, and the point of
um radiation on the radiation pattern shown below.



13. State the two resistances that combine to determine the i
impedance of an antenna.

14. Define polarization.

15. State the effect that a decrease in beam width has on the
antenna.

16. List five factors affecting the bandwidth of an antenna.

(1)

(2)

(3)

(4)

(5)

17. List three factors that affect the electrical length of a

(1)

(2)

(3)

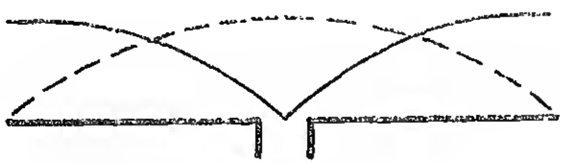
18. State the method used to compensate for end effect.

-1-3--Theory of Antennas

a.

Perpendicular to the antenna.

Parallel to the antenna.



The load appears inductive and resistive.

The load appears capacitive and resistive.

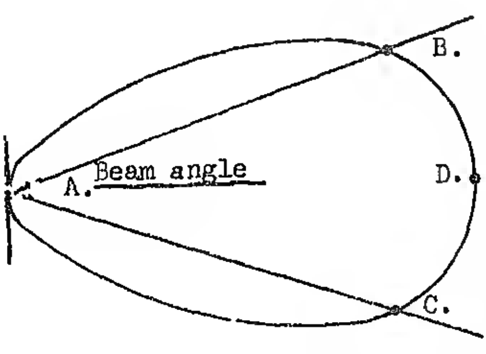
(1) b.

(2) a.

d.

b.

c.



Conductor resistance.

Radiation resistance.

The orientation of the electric field in the direction of radiat

Increases.

Radiation pattern.

Gain.

Polarization.

Impedance.

Side-lobe level.

Conductor material.

Conductor size.

End effect.

Make the antenna physically 5 per cent to 6 per cent shorter.